

'Dancing Triangles' Intrigue Chemists, Physicists

Karen McNulty Walsh

The pattern of triangles and hexagons shown here takes on an even more fascinating beauty when you realize it is made up of individual atoms. The image was made by Jan Hrbek, Acting Chair of the Chemistry Department, and collaborators from Sandia National Laboratory in Livermore, California, using scanning tunneling microscopy (STM). It shows the arrangement of sulfur atoms (bright spots) on a layer of copper over a ruthenium substrate.

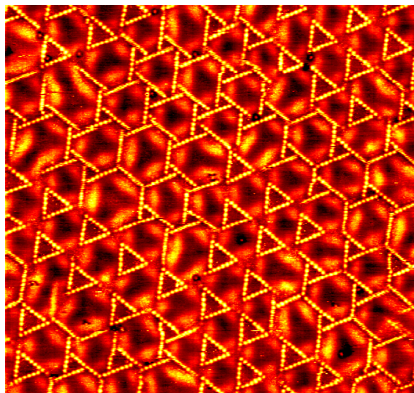
"We are trying to understand how one metal behaves on top of another, and how sulfur affects that interaction," Hrbek says.

Layered pairs of metals are commonly used in catalysts—such as those that clean pollutants from automobile exhaust in catalytic converters. Copper on ruthenium, Hrbek says, would make a particularly good model catalyst.

But sulfur, a common air pollutant, can "poison" the catalyst, destroying its effectiveness. "There is a lot of chemistry and physics involved in understanding this," he says.

Shining a light on the problem

Work being done at the National Synchrotron Light Source (NSLS) by Hubert Zajonz of the Physics Department and Doon Gibbs, leader of the Solid State Physics group in Physics, may shine some light on the problem, literally.



"Dancing Triangles"

The physicists are using x-rays to determine how metallic atoms like copper arrange themselves on ruthenium. "We want to know what the structures are as you put down more and more copper, how they change, and how that depends on temperature," Gibbs says.

Zajonz adds, "We think that this knowledge is crucial for understanding, controlling, and designing bimetallic catalysts."

By beaming x-rays at samples and studying how the beams scatter, the physicists can pinpoint how the atoms line up, and look for changes as copper atoms are added.

Using analytical techniques developed by Zajonz, the physicists have found that a single layer of copper atoms follows the layout of the ruthenium atoms in the substrate.

"But when you put down a second layer, even just one atom more than a single layer, there is a sizeable shift of positions," Gibbs says. The result is a striped pattern. Additional copper results in the formation of bulk copper "islands" about 100 atoms across.

The next step will be to look at the effect of adding sulfur.

Complementary approaches

With Hrbek's STM technique, which essentially scans the surface atom by atom using a needle-like probe, the sulfur atoms are seen to organize themselves into triangles and closely packed hexagons, while the copper stripes bend to form trigons. All this happens before the sulfur reacts chemically with the copper and alters the catalytic activity.

Hrbek describes the arrangement as dancing triangles: "If you want a pair to tango properly, you have to get them together. This is exactly what you see, sulfur moving around and trying to find the right place for getting together with copper."

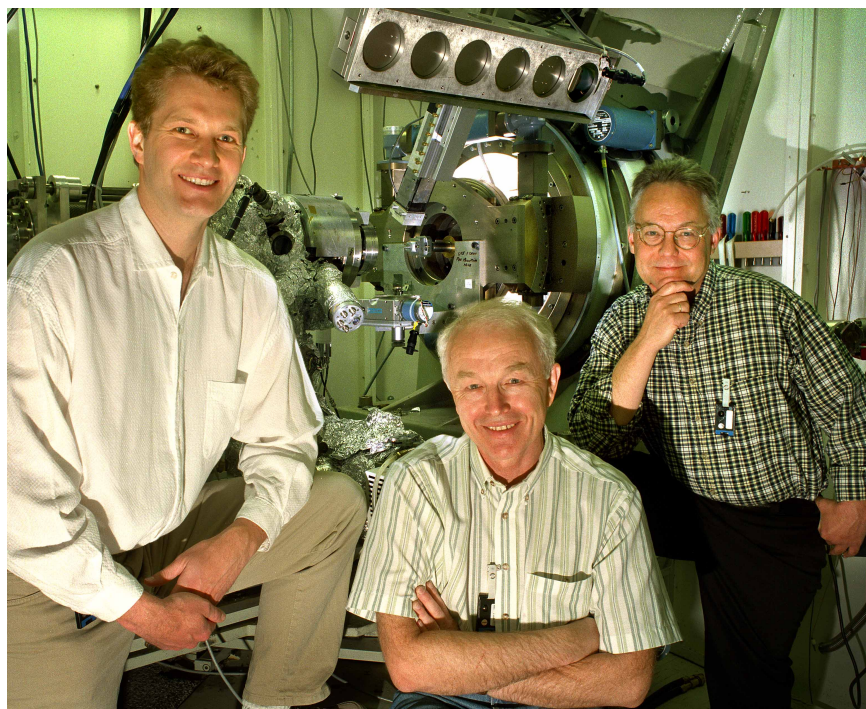
The x-ray technique, by contrast, scans larger areas and multiple layers, including the atoms in the ruthenium substrate. "It's completely complementary to STM," Gibbs says, "so it pays for us to work together."

Hrbek agrees, adding, "We can learn more by doing experiments in collaboration." Using both techniques will help establish whether the patterns Hrbek's group is observing occur over large areas.

In addition to helping scientists understand the catalytic reactions, the atomic arrangements of copper, ruthenium, and other metals might turn out to be useful for other purposes. For example, Hrbek says, one could imagine using the tiny grids as templates for building nanoscale structures, or using the techniques to make clusters of metallic particles with precisely controlled size distribution and chemistry.

"I have no idea what to use it for," says Gibbs, describing one of the intricate arrangements. But he wants to learn more, saying, "I think this is just beautiful."

[Editor's note: Reprinted with permission from the BNL Bulletin - May 25, 2001.]



At the National Synchrotron Light Source are: (from left) Hubert Zajonz, Physics Department, Jan Hrbek, Chemistry Department, and Doon Gibbs, Physics.